

REMARKS

Acceptance of the present Amendment as a submission in accordance with U.S. PTO RCE practice and withdrawal of the finality of the last Office Action are respectfully requested. Reconsideration and allowance of the above-identified application, as currently amended, is also respectfully requested.

Applicants again note with appreciation the indication that dependent claim 4 is directed to allowable subject matter and that it would be formally rendered allowable upon being re-presented in an independent claim format. As will be shown below, however, the invention set forth in independent claim 3 is defining over Noguchi et al (USP 6,172,380). Accordingly, Applicants consider it unnecessary to re-present the objected claim 4 as an independent claim.

By the above amendments, claims 21-24 were newly added and, correspondingly, claims 17-20 were cancelled, but, however, without prejudice or disclaimer of the subject matter therein. That is, claims 17-20 were cancelled strictly for the purpose of avoiding an added claim fee at this time and, therefore, Applicants reserve the right to re-admit these claims in either the present application or in connection with a continuing application which may be, for example, a divisional application. The new claims are being presented in consideration of further highlighting the structurally characterizing aspects of the set forth polycrystalline semiconductor thin film which is used in the formation of the transistors with regard to the schemed semiconductor device and which is defining over Noguchi et al. That is, as will be shown below, the invention according to independent claim 3 and, likewise, also according to the newly presented claims 21-24 was neither disclosed nor could have been achievable in view of Noguchi et al's teachings.

The invention according to independent claim 3 is directed to a semiconductor device including plural transistors that are formed in a polycrystalline semiconductor thin film in which the polycrystalline semiconductor thin film has a crystalline structure in accordance with plural laser irradiation steps. The polycrystalline semiconductor thin film defined in claim 3 is structured such that those crystal grains thereof with the number of closest crystal grains numbering (6) represents the largest lot of the same type of crystal grains that form the polycrystalline semiconductor thin film, upon completion of the last laser irradiation step in the manufacture thereof. In this regard, the claim calls for:

wherein...after the last laser irradiation step, the number of crystal grains with the number of closest crystal grains of 6 is greatest among plural crystal grains that form the polycrystalline semiconductor thin film.

According to the present invention, a transistor (such as a TFT) is formed in a polycrystalline semiconductor thin film structured such that the largest lot of crystal grains is characterized by crystal grains with the number of closest crystal grains thereto being 6.

An outcome of the improved polycrystalline semiconductor thin film for forming transistors of a semiconductor device according to the invention is the improvement of the uniformity of the surface of the polycrystalline semiconductor thin film and also in an increase in the number of hexagonal crystal grains from the number typically associated with the manufacture of polycrystalline semiconductor thin films. An example of an hexagonal crystal grain formation in a polycrystalline semiconductor thin film featuring numerous crystal grain shapes and which especially shows the tightly joined grain boundaries of hexagonal crystal grains can be seen with regard to Fig. 9(b) of the drawings (see also Fig. 5 as well as Fig. 8[b]).

Such a schemed polycrystalline semiconductor thin film is realized only after plural laser irradiation steps are completed (see page 22, lines 7-22, of the specification). Additional discussion regarding an example of an arrangement of crystal grains with the number of closest crystal grains of 6 representing the largest lot among the overall number of crystal grains that form such improvement in the polycrystalline semiconductor thin film is provided on page 18, line 10, to page 26, line 16, of the present specification. It is submitted such a schemed semiconductor device as that presently set forth in claim 3 was neither disclosed nor could have been realizable in view of Noguchi et al.

In the *Modern Dictionary of Electronics* (Sixth Edition, revised and updated, 1997), authored by R. F. Graf, polycrystalline material is defined as *material, typically an element like silicon or germanium, made up of many single crystals having a random orientation....* This dictionary further defines polycrystalline structure as *the granular structure of crystals which have non-uniform shapes and arrangements.* Such is consistent with a polycrystalline structure according to the present invention, with the exception of the further attributes thereof recited in independent claim 3:

wherein...after the last laser irradiation step, the number of crystal grains with the number of closest crystal grains of 6 is greatest among plural crystal grains that form the polycrystalline semiconductor thin film.

In order to highlight the fact that the polycrystalline semiconductor thin film characteristically has non-uniformly oriented crystal grains and also that a relationship does not exist between that of a crystalline orientation and a shape of the crystalline surface in which the polycrystalline semiconductor thin film has many crystalline orientations, independent claim 21 as well as corresponding dependent claims 23 and 24 were accordingly added. Dependent claim 22 is similar to claim 4

but, however, has as a basis independent claim 21. It is submitted, therefore, that claims 21-24 are likewise patentable over Noguchi et al.

The semiconductor device of the present invention features a polycrystalline semiconductor thin film which characteristically has many crystalline orientations, i.e., the crystalline orientations are not uniform, in clear contradistinction with that disclosed or, for that matter, taught by Noguchi et al. As is shown below, the present invention is directed to quite a different concept from that according to Noguchi et al's disclosure. Attached hereto are Sketches (a), (b) and (c) for purposes of illustrating the differences in the crystalline orientations of the crystal grains (e.g., $\langle 001 \rangle$ (red), $\langle 101 \rangle$ (green), $\langle 111 \rangle$ (deep blue) and others between them. That is the thin film has numerous crystalline orientations. The Sketch (a) is a SEM image after mapping of an electron back scattering for a polycrystalline semiconductor thin film according to the present invention. Sketch (b) shows the result of the mapping of the electron back scattering and it is an IPF Map, that is, a drawing showing crystalline orientations of the crystal grains corresponding to the SEM image of Sketch (a). A surface of the substrate of the crystal growth is a (001) plane. In the sketch, each crystal grain is colored on the basis of the corresponding crystal plane. Sketch (c) shows a relationship between the many crystalline orientations of the crystal grains and many colors. In Sketch (c), $\langle 001 \rangle$ is red, $\langle 111 \rangle$ is deep blue, $\langle 101 \rangle$ is green and the other colors correspond to other parts of other rotation angles. Sketch (b) shows a mixture of some crystalline orientations of the crystal grain, for example, $\langle 001 \rangle$ (red), $\langle 101 \rangle$ (green), $\langle 111 \rangle$ (deep blue) and others. It is submitted, on the basis of this and the detailed discussion in the present specification, there is no relationship between that of a crystalline orientation and a

shape of a crystalline surface of a polycrystalline semiconductor thin film according to the present invention. Further, the polycrystalline semiconductor thin film of the present invention contains many crystalline orientations.

As discussed in the present specification, the inventors experimented on the crystallization of amorphous silicon thin film by using the excimer laser annealing. The surface of the thin film was evaluated in such a way that the grain boundary was photographed by a SEM (Scanning Electron Microscope). In their investigation of this, they observed that the grain boundary is always not a straight line and that the outline of the crystalline grain is basically a polygon. Therefore, it is reasonable to consider that a crystalline grain is principally shaped like a polygon. Further, in addition to observing the formations or shapes of the crystal grains, consideration was also given of to how to fill up or compact a crystal. In this regard, the inventors observed how many grains adhere around a single crystal grain (this is referred to as the number of closest crystal grain N). The relationship between the number of closest crystal grain N and an electrical characteristic of a thin film transistor was investigated. On the basis of these investigative studies, Applicants have been able to achieve the present invention through applying plural laser irradiation steps to realize the growth of grains from that of Fig. 9(a) to that of Fig. 9(b) (see also Figs. 5 and 8(b)).

Noguchi et al disclose the formation of a semiconductor film that is dominated by a single orientation of grains, and, also, that the shape of the surface formed corresponds to the crystal orientation. The shapes of the grains of the present invention, however, do not correspond to a crystal orientation and, additionally, the forms or shapes of the grains are many. In fact, a thin film according to the present

invention is filled or has a compact arrangement of grains having various forms, whose number of closest crystal grain N is 6.

Noguchi et al disclose forming a semiconductor material in which the crystal grains thereof are preferentially oriented in a common surface orientation. Noguchi et al's four disclosed embodiments all feature a semiconductor material with an arrangement of crystal grains that have a uniform preferential orientation. In Noguchi et al's first embodiment, the arrangement of crystal grains are preferentially {100}-oriented (see column 3, lines 22-24 in Figs. 1-2). Regarding Noguchi et al's second disclosed embodiment in Fig. 10, the crystal grains thereof are preferentially {111}-oriented (see column 5, lines 20-34). As to Noguchi et al's third disclosed embodiment, the semiconductor film features single-crystal grains 3a which are preferentially {100}-oriented (see column 5, lines 35-56 and Fig. 11). Similarly, regarding Noguchi et al's fourth featured embodiment, the semiconductor film characteristically has uniformly arranged single type of crystal grains 3a which are of hexagonal shape and which are preferentially {110}-oriented (see column 5, line 57, to column 6, line 5 and Fig. 12).

According to Noguchi et al the semiconductor material is made of substantially single crystalline semiconductor crystal grains (e.g. 3a in Figs. 1-2, 10, 11 and 12) which are preferentially oriented in a common surface orientation, such as {100}, {111} or {110} orientation. Such a characteristically formed semiconductor material is quite different from a polycrystalline material/polycrystalline structure defined in the above-noted Dictionary by Graf. Graf also defines single crystal as a *piece of material in which the crystallographic orientation of all the basic groups of atoms is the same*. Accordingly, Noguchi et al rightfully make reference to their

formed semiconductor material as a "substantially single-crystalline semiconductor." It is submitted, a semiconductor film as that disclosed or, for that matter, taught by Noguchi et al is characteristically different from that according to independent claims 3 and 21 and correspondingly also the dependent claims thereof.

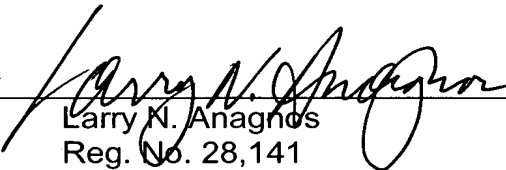
Noguchi et al states that the second, third and fourth disclosed embodiments thereof, respectively, *can be made by the process explained with the SOI structure according to the first embodiment.* (Column 5, lines 30-32; column 5, lines 51-53; and column 6, lines 1-3, in Noguchi et al.) However, one cannot assume on the basis of Noguchi et al's teaching that many different types of polycrystalline semiconductor thin films each of which having a different dominating orientation would be formed by the same process. It is observed that each of the disclosed embodiments of Noguchi et al have a similar crystallographic form featuring a single crystalline orientation, which is clearly unlike that of the present invention. It is also reasonable to consider that a technique in the formation of the crystalline grain forms in the completed semiconductor thin film would require a special technique. However, Noguchi et al makes no reference or hint at such a special technique or process. It is reasonable to assume therefore that Noguchi et al did not disclose or teach the forming of thin film transistors in a polycrystalline semiconductor thin film as characteristically set forth in independent claim 3 and claims 21-24.

For at least the above reasons, the invention according to claims 3+ and 21+ could not have been anticipated nor, for that matter, realizable in view of Noguchi et al. Therefore, withdrawal of the outstanding rejection as well as favorable action on the pending claims 3-4 and 21-24 together with an early formal notification of allowance of the above-identified application is respectfully requested.

To the extent necessary, Applicants petition for an extension of time under 37 C.F.R. §1.136. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to the Antonelli, Terry, Stout & Kraus, LLP Deposit Account No. 01-2135 (Docket No. 520.41003X00), and please credit any excess fees to such Deposit Account.

Respectfully submitted,

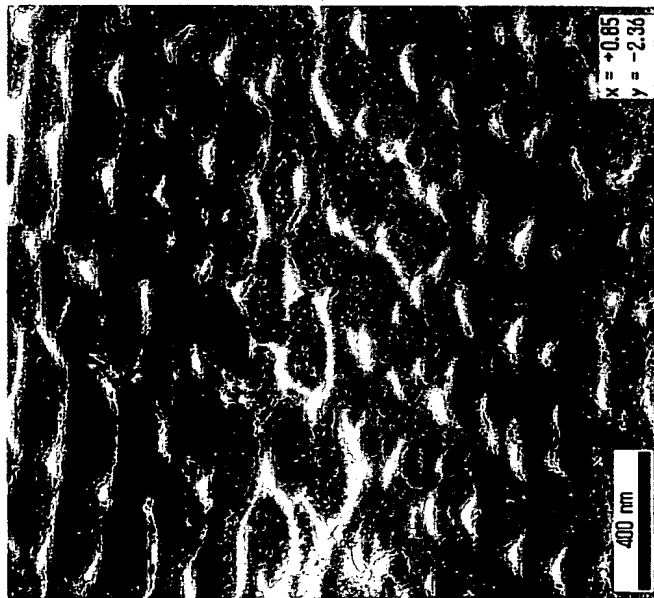
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APPENDIX

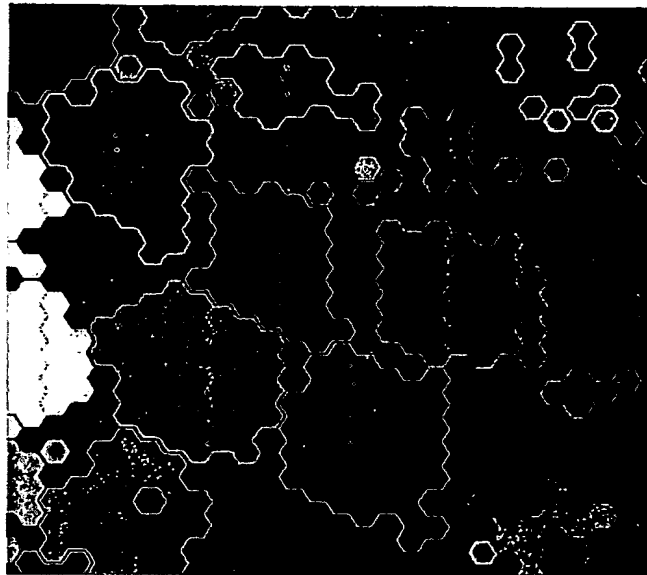
SKETCH (a)



マッピング後の SEM 像

SEM image after mapping

SKETCH (b)



IPF Map (ND 方向)

IPF Map (ND direction)

Gray Scale Map Type: <none>

Color Coded Map Type: Inverse Pole Figure [001]

fcc_generic

111

SKETCH (c)



001

101

Orientation: Rotation angle

Min Max Fraction

15 180 0.814

*For statistics - any point pair with misorientation exceeding 2° is considered a boundary

*Modern
Dictionary
of Electronics*

SIXTH EDITION

**REVISED
and UPDATED**

Rudolf F. Graf

mission line is re-hanging from mark-

f a magnet. 2. One y. 3. An output terminal. An item that connects circuit. 5. A combining mating contacts. 7. the end of the magnetic armature.

more pieces of ferro-forming one end of a ped that the distributive flux in the adjacent is controlled. portion of a field pole re of the machine. It from the body of the

function—Those real of p for which the net-infinite.

transformer—A transformer ing on a pole or similar

roadcasts (usually orders) radio stations.

on—The direct link by system is connected to an tallied in a police station. police connection are an l a radiocommunications

the adjustment of polarity. wire-line practice, it signifies transpositions between sections of open wire or be-of cable, to cause the residual couplings in individual sections to oppose one another. 2. production of ceramic piezoelectric materials which orients the axes of in the preferred direction. process similar to magnetization of materials.

A mechanical finishing operation upon solid-state substrate to achieve smoothness and desired properties. Also see Lapping. 2. Act of grinding ends of fibers to an optically smooth surface, generally using abrasives. smooth surfaces allow maximum transmission of light between fibers and minimum coupling

ation—A system for writing and logical and arithmetic without the use of parentheses because it was originated by logician J. Lukasiewicz.

Periodic interrogation of each terminal that share a communication to determine whether it is servicing. The multiplexer or station sends a poll that has the asking the selected terminal, have anything to transmit?" 2. A

means of controlling communication lines. The communication control device will send signals to a terminal saying, "Terminal A, have you anything to send?" If not, "Terminal B, have you anything to send?" and so on. Polling is an alternative to contention. It makes sure that no terminal is kept waiting for a long time. 3. Controlling communication lines by designating one station as the master. This station then gives control of the line to each of the other stations, in turn, for a predetermined amount of time. 4. A communications feature that allows one or more stations of a communicating word-processing system to check with other systems to see if a message is ready to be sent. 5. A centrally controlled method of calling a number of points to permit them to transmit information. 6. A control message sent from a master site to a slave site that serves as an invitation to transmit data to the master site. 7. Scheduling technique for i/o devices, where the program interrogates in turn the status of each peripheral, and gives service when required. The other essential techniques are interrupts and direct memory access. 8. A process in which a number of peripheral devices, remote stations, or nodes in a computer network are interrogated one at a time to determine if service is required. 9. Refers to a centrally controlled method of permitting multiple requesters on a single line to transmit information without contention. 10. In data communications, the action of the central system periodically requesting input from multiple terminals on a line by sending a predetermined message (known as a poll sequence) to the terminals.

poll response—See Train Time.

polycarbonate—An amorphous thermoplastic used in the connector industry and offering high impact strength over a broad temperature range. Polycarbonates are excellent electrical insulators over a wide range of humidity and temperature. They are used as dielectrics in film capacitors. They have a high resistance to creep.

polychromatic radiation—Electromagnetic radiation consisting of two or more frequencies or wavelengths.

polycrystalline ceramic—A ceramic material, such as barium titanate, with a crystalline structure in which all molecules are similarly oriented and regularly arranged. (It may be made piezoelectric by pretreatment with a polarizing electric field.)

polycrystalline material—Material, typically an element like silicon or germanium, made up of many single crystals having a random orientation. The term may be applied to a twin crystal as well as

to a heterogeneous growth of many crystals.

polycrystalline structure—The granular structure of crystals which have non-uniform shapes and arrangements.

polyergic—A type of emission in which the groups of energies or velocities are produced simultaneously (e.g., simulated micrometeoroids in varying charge states, separated by velocity where accelerated by the same potential).

polyester—Polyethylene glycol terephthalate, the material most often used as a base film for precision magnetic tape. The chief advantages of this material compared to other materials are its stability with respect to humidity and time, its resistance to solvents, and its mechanical strength. It is used as a dielectric in film capacitors.

polyester backing—A plastic-film backing added to magnetic tape to make it stronger and more resistant to changes in humidity.

polyester base—A plastic-film backing for magnetic tape used for special purposes where strength and resistance to temperature and humidity change are important. (Mylar is a Du Pont trade name for their brand of polyester.) 2. A plastic film material widely used as a backing for magnetic tape.

polyester films—A broad category of films that differ in chemical composition, properties, and processability, but which exhibit very good electrical properties.

polyesters—A class of thermosetting synthetic resins having great strength and good resistance to moisture and chemicals.

polyethylene—Short for polymerized ethylene, a tough white plastic insulator with low moisture absorption. It is often used as a dielectric.

polygon—A closed figure with straight edges; often used as the underlying 3-D data structure for shaded-3-D systems.

polygraph—Also called a lie detector. A recorder of several signals simultaneously, such as blood pressure, respiratory motion, galvanic skin resistance, etc., commonly used for study of emotional reactions involving deception (lie detection).

polyimide film—A plastic film exhibiting excellent physical and electrical properties over a wide temperature range. Produced from pyromellitic dianhydride and an aromatic diamine, it is used as a printed-circuit substrate.

polymer—A compound formed by polymerization which results in the chemical union of monomers or the continued reaction between lower molecular weight polymers.

polynomial—An algebraic expression that contains two or more terms and in which the dependent variable is repre-

sion of control characters or data in one direction at the same time that information is being received in the opposite direction.

sinad — A measurement of the signal-to-noise ratio of a receiver system where the signal level measurement includes the system noise and distortion: $(s + n + d)/n$.

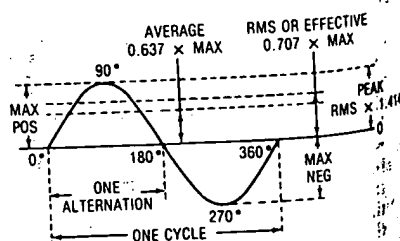
sine — The sine of an angle of a right triangle is equal to the side opposite that angle, divided by the hypotenuse (the long side opposite the right angle).

sine galvanometer — An instrument resembling a tangent galvanometer except that its coil is in the plane of the deflecting needle. The sine of the angle of deflection will then be proportionate to the current.

sine law — The law which states that the intensity of radiation in any direction from a linear source varies in proportion to the sine of the angle between a given direction and the axis of the source.

sine potentiometer — A dc voltage divider (potentiometer), the output of which is proportionate to the sine of the shaft-angle position.

sine wave — 1. A wave which can be expressed as the sine of a linear function of time, space, or both. 2. A waveform (often viewed on an oscilloscope) of a pure alternating current or voltage. It is drawn on a graph of amplitude versus time or radial degrees and follows the rules of sine and cosine values in relation to angular rotation of an alternator. It can be simulated by means of an electronic oscillator. 3. The only waveform which cannot be considered to be a "pulse." All other waveforms consist of more than one frequency, all harmonically related. A sine wave has a single frequency and therefore occupies a very small bandwidth. It passes through circuitry of any bandwidth, with no change in waveform, but it may be changed in amplitude.



Sine wave.

sine-wave modulated jamming — A jamming signal consisting of a cw signal modulated by one or more sine waves.

singing — 1. An undesired self-sustained oscillation at a frequency in or above the passband of a system or component. 2. An

unwanted self-sustained audio-frequency oscillation in an audio system or device.

singing margin — Also called gain margin. The excess of loss over gain around a possible singing path at any frequency, or the minimum value of such excess over a range of frequencies.

singing point — 1. The condition of a circuit or transmission path where the sum of the gains exceeds the sum of the losses. When expressed in decibels, it is the gain that can be added to the circuit equivalent before singing will begin. 2. The amount of total gain in the transmission system (most commonly used in connection with two-wire repeaters) which causes the system to begin to lose efficiency of performance because the self-oscillating point is too closely approached. 3. The singing point of a circuit which is coupled back to itself is the point at which the gain is just sufficient to make the circuit break into oscillation.

singing-stovepipe effect — Reception and reproduction of radio-signal modulation by ordinary pieces of metal, such as sections of stovepipe, in contact with each other. It is caused by mechanically poor connections, such as rusty bolts or faulty welds, that act as nonlinear diodes and produce intermodulation distortion when subjected to strong radiated fields near transmitters.

single-address code — An instruction which contains the location of the data and the operation or sequence of operations to be performed on this data.

single amplitude — With reference to vibratory conditions, the peak displacement of an oscillating structure from its average or mean position.

single-anode tank — See Single-Anode Tube.

single-anode tube — Also called a single-anode tank. An electron tube with one anode (used chiefly for pool-cathode tubes).

single-axis gyro — A type of gyro in which the spinning rotor is mounted in a gimbal arranged so as to tilt about only one axis relative to the stable element.

single-board microcomputer — Also called monoboard microcomputer. A single printed-circuit board containing, as a minimum, processor, memory (ROM and/or RAM) and input/output—usually a combination of serial and parallel ports. May also include a counter/timer function and bus interconnection scheme. A "single-board microcomputer family" may also include other functional system elements (such as memory and i/o functions) on circuit boards of the same format as the microcomputer board.

single-button carbon microphone — A microphone having a carbon-filled buttonlike container on one side of its flexi-

ble diaphragm. As the sound waves move the diaphragm, the resistance of the carbon changes, and the microphone current constitutes the desired audio-frequency signal.

single-carrier fm recording — The method of recording in which the input signal is frequency-modulated onto a carrier and the carrier is recorded on a single track at saturation and without bias.

single-channel — A carrier-only or single-tone modulated radio control transmitter and matching receiver installation.

single-channel monopulse tracking system — See Monopulse Tracking.

single-channel simplex — Nonsimultaneous communication between stations over the same frequency channel.

single circuit — A telegraph circuit capable of nonsimultaneous two-way communication.

single circuit system — An alarm circuit which routes only one side of the circuit through each sensor. The return may be through either ground or a separate wire.

single-conversion receiver — A receiver employing a superheterodyne circuit in which the input signal is downconverted once.

single crystal — A piece of material in which the crystallographic orientation of all the basic groups of atoms is the same.

single-degree-of-freedom system — A system for which only one coordinate is required to define the configuration of the system.

single-dial control — Control of a number of different devices or circuits by means of a single adjustment (e.g., in tuning all variable-capacitor sections of a radio receiver).

single-ended — Unbalanced such as grounding one side of a circuit or transmission line.

single-ended amplifier — An amplifier in which only one tube or transistor normally is employed in each stage—or if more than one is used, they are connected in parallel so that operation is asymmetric with respect to ground.

single-ended input — Amplifier input configuration in which all analog inputs are referenced to system ground.

single-ended input impedance — The impedance between one amplifier input terminal and ground (with the other input terminal, if any, grounded for ac) when the amplifier is balanced.

single-ended input voltage — The signal voltage applied to one amplifier input terminal with the other input terminal at signal ground.

single-ended output voltage — The signal voltage between one amplifier output terminal and ground.

single-ended push-pull amplifier circuit — An amplifier circuit having two